

IMPROVING LUNAR EXPLORATION WITH ROBOTIC FOLLOW-UP. T. Fong¹, M. Bualat¹, M. Deans¹, E. Heggy², M. Helper³, K. Hodges⁴, and P. Lee⁵. ¹NASA Ames Research Center, Moffett Field, CA, terry.fong@nasa.gov. ²Jet Propulsion Laboratory, ³Univ. of Texas / Austin, ⁴Arizona State Univ., ⁵Mars Institute.

Introduction: We are investigating how augmenting human field work with subsequent robot activity can improve lunar exploration. Robotic “follow-up” might involve: completing geology observations; making tedious or long-duration measurements of a target site or feature; curating samples in-situ; and performing unskilled, labor-intensive work. To study this technique, we have begun conducting a series of lunar analog field tests at Haughton Crater (Canada).

Motivation: In most field geology studies on Earth, explorers often find themselves left with a set of observations they would have liked to make, or samples they would have liked to take, if only they had been able to stay longer in the field. For planetary field geology, we can imagine mobile robots – perhaps teleoperated vehicles previously used for manned exploration or dedicated planetary rovers – being deployed to perform such follow-up activities [1].

Robotic rovers will be needed on the Moon. Both the National Research Council [2] and the NASA Advisory Council [3] identify key roles for robots. The NAC report states that “to achieve the highest-ranked lunar science objectives, continued robotic sortie missions will be needed, before and after human presence is established”.

Humans themselves will be on the Moon. Because humans are able to explore the Moon in-situ, robotic rovers do not need to be conceived as primary (or sole) science instruments. Instead, robots may be designed to perform rote, tedious, or long-duration follow-up tasks and enable humans to focus on activities that require human intelligence, skills and decision-making.

Substantial time is available for robotic follow-up work. With the “Global Exploration Strategy” [4], there will be substantial amounts of time and opportunities to use robotic assets positioned on the Moon to perform work. Robotic rovers could be put to good use during the time between crews to finish a variety of field work tasks and to prepare for future crews.

We do not know how to use robotic follow-up for human exploration. While the notion of operating robots to complete work started by humans is conceptually simple, many unknowns become quickly apparent if one attempts to establish a practical lunar concept of operations. Even on Earth, little has been done to study, assess, and document the impact and value of robotic follow-up in support of humans.

Field Tests: In July 2010, we conducted the first of a series of field tests at the Haughton Crater impact structure on Devon Island, Canada [5]. In this test, we

remotely operated a K10 planetary rover equipped with a variety of instruments (3D scanning lidar, color imagers, XRF spectrometer, and ground-penetrating radar) to perform follow-up work.



K10 planetary rover at Haughton Crater

Robotic follow-up for sample characterization involved extending in time, space, and detail, the general geologic characterization by a human crew of key areas in and around Haughton Crater. In our field work, we focused on characterizing in greater depth the composition (petrography and mineralogy), distribution, and geologic context, of major lithologies. We paid special attention to Haughton's distinctive impact breccia materials in order to characterize the major types of clasts and textures encountered in them.

Robotic follow-up for systematic mapping involved investigating the near-subsurface structure and 3-D distribution of ground ice at Haughton as an operational analog to investigating near-subsurface volatiles on the Moon. In our field work, we focused on performing transect surveys so that 3D maps of the structure of the near-subsurface and the distribution of ground ice in different substrates could be constructed.

Observations: Based on our initial field testing, we have identified key differences between robotic exploration (e.g., as done by the Mars Exploration Rovers) and robotic follow-up. In particular, whereas robot explorers serve as principal science tools, the primary function of robotic follow-up is to augment and complete human field work. This has significant implications for mission design and science operations.

References: [1] Hodges, K. and Schmitt, H.H (2010) GSA Special Paper: Analogs. [2] NRC (2007) “The Scientific Context for Exploration of the Moon: Final Report”. [3] NASA Advisory Council (2008) NP-2008-08-542-HQ. [4] ISECG (2009) Global Exploration Strategy. [5] Fong, T., et al. (2010). “Robotic Follow-up for Human Exploration” AIAA Space 2010.